

## STRUCTURE OF THE HELMINTH ASSEMBLAGE OF AN ENDEMIC MADTOM CATFISH (*NOTURUS LACHNERI*)

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The Ouachita madtom, *Noturus lachneri*, is a small, uniformly-colored catfish endemic to the upper Saline and Ouachita river drainages in central Arkansas (Robison and Buchanan, 1988), where it is often found in shallow pools associated with clear, high gradient, rock-bottomed streams (Robison and Harp, 1985). Distribution, habitat, diet, and conservation status of *N. lachneri* were examined by Robison and Harp (1985). However, information on parasites of this endemic species has not been reported. Herein, we report on species richness and mean abundance of helminth parasites of *N. lachneri*.

Compared to free-living organisms, parasite assemblages are spatially well-defined and show distinct levels of hierarchical organization (Poulin, 1997). All parasites within a single host constitute an infracommunity, whereas all helminths in a host population define the component community (Holmes and Price, 1986). At the infracommunity scale many replicates are possible because each individual host within a population of hosts constitutes a fully censused assemblage. Therefore, parasite assemblages provide an excellent system for hypothesis testing in community ecology (Poulin, 1997).

Parasites often influence critical aspects of the life-history and ecology of their host species. For example, parasites can affect reproduction (Tinsley, 1990), growth (Lim and Green, 1991), behavior (Kennedy et al., 1987; Houde and Torio, 1992; Bronseth and Folstad, 1997), and mortality rates (Jaenike et al., 1995; Rousset et al., 1996). Therefore, it is important to understand how these organisms affect the biology of host species, especially species of concern such as the endemic *N. lachneri* (Robison and Harp, 1985).

We examined several aspects of the parasite

assemblage structure of this host species including the identity of each helminth species and its prevalence (% of infected hosts in a sample), mean abundance (mean number of worms per host, including both infected and uninfected hosts), and mean intensity (mean number of worms per infected host—Bush et al., 1997). We also identified size-dependent patterns of parasite load (total number of worms per host, including individuals of all parasite species in a host) and helminth species richness, and suggest possible effects on survivorship of this endemic fish species.

Electroshocking was used to collect 27 *N. lachneri* from the upper Saline River drainage, Saline Co., Arkansas, in February 1997. Specimens were euthanized with MS-222 and preserved in 10% formalin. We examined all visceral organs and mesenteries for helminth parasites. Wet mounts of all helminths were viewed with an American Optical® compound microscope, and parasites were identified with the use of taxonomic keys (Mueller and Van Cleave, 1932; Schell, 1985; Schmidt, 1970; Petrochenko, 1971; Stromberg et al., 1973). Trematodes, acanthocephalans, and cestodes were stored in AFA (alcohol-formalin-acetic acid), and nematodes were placed in glycerin alcohol. Voucher specimens were deposited in the United States National Parasite Collection (accession numbers 88500–88503).

A scatter plot of length versus mass was used to identify discrete size classes of *N. lachneri*. Because our data violated some assumptions for parametric statistical analysis, Kruskal-Wallis tests were used to determine whether mean parasite load and mean species richness differed among size classes. Multiple comparisons among size classes were made with Mann-Whitney tests. Probability values of these comparisons were adjusted with a sequential Bonfer-

TABLE 1—Prevalence, mean abundance, mean intensity, and infection site of the intestinal helminths of *N. lachneri* (n = 27).

Helminths	Prevalence	Mean abundance ± SE	Mean intensity ± SE (range)	Infection site
Trematoda				
<i>Alloglossidium corti</i>	93%	7.1 ± 1.7	7.7 ± 1.8 (1–43)	SI
Acanthocephala				
<i>Leptorhynchoides thecatus</i>	30%	0.37 ± 0.12	1.25 ± 0.16 (1–2)	SI
Cestoda				
<i>Proteocephalus</i> sp. <sup>1</sup>	15%	0.44 ± 0.25	3.0 ± 1.16 (1–5)	MES
Nematoda				
<i>Camallanus oxycephalus</i>	4%	0.07 ± 0.07	2.0 (2)	LI
<i>Spinitectus carolini</i>	4%	0.04 ± 0.04	1.0 (1)	SI

<sup>1</sup> Larval helminths, SI = small intestine, LI = large intestine, MES = mesenteries.

roni correction to control experiment-wise error rate (Rice, 1989). All measures are given as mean ± standard error.

A total of 217 worms representing five helminth species (one Trematoda, one Acanthocephala, one Cestoda, two Nematoda) was collected from the small and large intestine and mesenteries (Table 1). Infracommunity species richness was low, as most individuals (n = 16) were infected with one helminth species. Seven

fish harbored two helminth species and three *N. lachneri* showed an infracommunity richness of 3; one individual was not infected with helminth parasites (Fig. 1). Mean infracommunity species richness and mean parasite load were 1.4 ± 0.1 helminth species per host and 8.0 ± 1.8 worms per host, respectively.

The most prevalent and abundant helminth was *Alloglossidium corti* (192 of 217 total worms obtained), a common parasite of other *Noturus* species (Hoffman, 1967). This trematode was found in the small intestine of 25 *N. lachneri* and showed the greatest prevalence, mean abundance, and mean intensity (Table 1). Mayfly naiads (Ephemeroptera) are the second intermediate host species of *A. corti* (Schell, 1985 and references therein). Ephemeropterans also have been reported to be common prey items of *N. lachneri* (Robison and Harp, 1985).

The acanthocephalan *Leptorhynchoides thecatus*, which uses amphipods as an intermediate host (DeGiusti, 1949), occurred in 30% of fish, but mean abundance and mean intensity of this parasite were low (Table 1). We have collected amphipods in large numbers from isolated pools in the upper Saline River drainage, but they are relatively uncommon in flowing stream reaches where fish are present (R. A. Fiorillo, pers. obser.). Robison and Harp (1985) found that *N. lachneri* did not commonly prey on amphipods. This spatial segregation

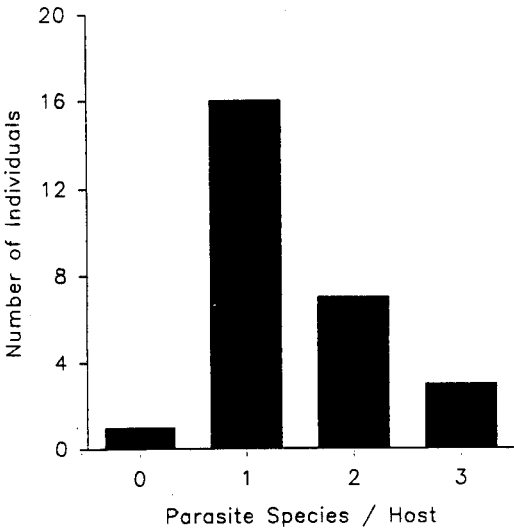


FIG. 1—Frequency of helminth infracommunity species richness of *N. lachneri*.

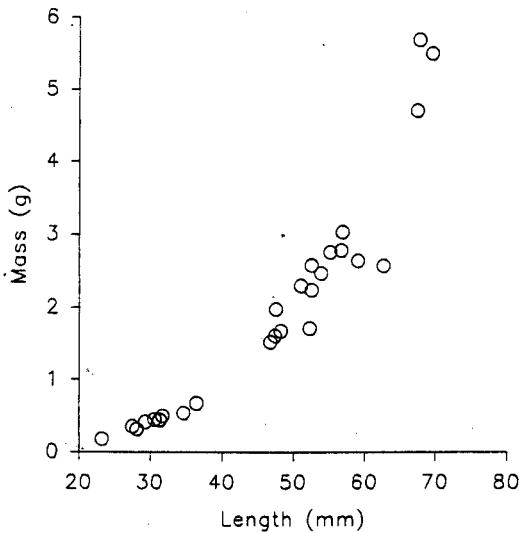


FIG. 2.—Length versus mass scatter plot showing three size classes of *N. lachneri*.

of *N. lachneri* and amphipods might explain the lack of amphipods in the diet of *N. lachneri* and the low mean abundance and mean intensity of *L. thecatus*. Alternatively, Ewald and Nickol (1989) concluded that population size of *L. thecatus* in green sunfish (*Lepomis cyanellus*) is dependent on availability of cecal space. The digestive system of *N. lachneri* lacks these diverticula and may represent an unsuitable habitat for this parasite.

The nematodes *Camallanus oxycephalus* and *Spinitectus carolini* and the cestode *Proteocephalus* sp. were rare and showed low mean abundances and mean intensities (Table 1). The intermediate host species of *C. oxycephalus* and *Proteocephalus* sp. are cyclopoid copepods (Hoffman, 1967; Stromberg and Crites, 1974). These crustaceans are common to lentic systems but are found rarely in rapid-flowing streams (Pennak, 1989), such as those inhabited by *N. lachneri*. Therefore, the ability of these helminths to colonize this host species may be restricted by ecological barriers associated with environmental requirements of their intermediate host species.

Based on standard length (mm) and body mass (g), we identified three size classes of *N. lachneri*: size class 1 ( $30.4 \pm 1.7$  mm,  $0.43 \pm 0.04$  g,  $n = 10$ ), size class 2 ( $53.1 \pm 1.3$  mm,  $2.28 \pm 0.13$  g,  $n = 14$ ), and size class 3 ( $68.3 \pm 0.7$  mm,  $5.3 \pm 0.3$  g,  $n = 3$ ; Fig. 2). Mean

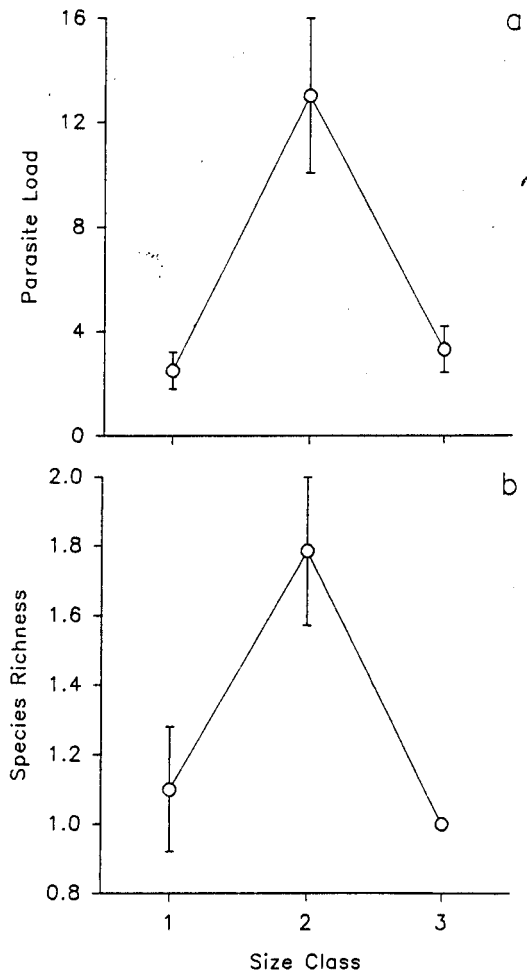


FIG. 3.—Mean parasite load  $\pm$  SE a), and mean parasite species richness  $\pm$  SE b) of three size classes of *N. lachneri*.

parasite load differed among size classes (Kruskal-Wallis,  $P = 0.001$ ). It was lowest in class 1, increased significantly in size class 2 individuals (Mann-Whitney,  $P = 0.002$ ), and decreased in class 3 (Mann-Whitney,  $P = 0.06$ ; Fig. 3a). There was no difference in mean parasite load among *N. lachneri* size classes 1 and 3 (Mann-Whitney,  $P = 0.43$ , Fig. 3a). Helminth species richness differed significantly among size classes (Kruskal-Wallis,  $P = 0.05$ ), but because of lack of variance among individuals in class 3, multiple comparisons among these groups were not statistically possible. However, mean helminth species richness did show a pattern similar to mean parasite load (Fig. 3b).

Helminth species richness (at both the infra- and component community scales) and mean abundance (infracommunity) of *N. lachneri* were low and did not differ qualitatively from other freshwater fishes (Kennedy et al., 1986). A simple enteric system, ectothermy, and low vagility are possible factors contributing to the depauperate nature of the helminth assemblage of this and other fish host species (Kennedy et al., 1986). The diversity of potential intermediate hosts also may play an important role in determining the parasite species richness of a definitive host. Finally, several authors have shown that component community richness is highly correlated with geographical range of the host species (Price and Clancy, 1983; Gregory, 1990; Marcogliese and Cone, 1991). These studies suggest that a large geographical distribution exposes a host species to colonization by a greater number of helminths (review in Poulin, 1997). Robison and Harp (1985) have shown that *N. lachneri* is endemic to the upper Saline and Ouachita river drainages, therefore the restricted range of this madtom may be an important determinant of its helminth species richness and mean abundance patterns.

All helminths collected in this study use intermediate hosts in their life-cycles, and *N. lachneri* is infected with these parasites by feeding on intermediate hosts that harbor larval stages of these worms. The increase in mean number of worms in size class 2 individuals could result from ontogenetic changes in diet from smaller to larger prey items such as mayfly naiads, which serve as an intermediate host of *A. corti*. Alternatively, older individuals may simply have had more time to be colonized by these helminths. We concede that the low parasite load and helminth species richness of class 3 individuals may be a result of small sample size, but this pattern suggests that heavily parasitized individuals may experience greater mortality. An uneven parasite distribution pattern among size classes may be evidence of parasite-induced mortality (Anderson, 1978, 1991; Anderson and Gordon, 1982; Pacala and Dobson, 1988).

This study is the first survey of helminth parasites of *N. lachneri*. The helminth assemblage of this host species was species poor and comprised of distantly related species that overall showed low mean abundances and mean in-

tensities. These are all characteristics of an isolationist helminth community as described by Holmes and Price (1986). The trematode *A. corti* was the most prevalent and abundant parasite, but all other helminths were uncommon. Biotic and abiotic barriers may reduce the ability of these uncommon helminths to colonize this host species. An uneven parasite distribution among size classes of *N. lachneri* was noted, suggesting possible parasite-induced mortality. Because of its restricted range and possible status as a species of concern, we believe that effects of these parasites on survivorship and other aspects of the life history and ecology of this host species warrant further investigation.

**Resumen**—Un total de 27 *Noturus lachneri* fue examinado para los parásitos helmintos. La comunidad de parásitos de esta especie anfitriona se caracteriza de pocas especies, no parientes y por lo general con abundancias e intensidades bajas. *Alloglossidium corti* (Tremátoda) fue el helminto más frecuente y más abundante, pero los demás helmintos no fueron comunes. Las barreras bióticas y abióticas pueden reducir la capacidad de los helmintos no comunes para la colonización de esta especie anfitriona. Aunque nuestro tamaño de muestra de la clase 3 de tamaño era pequeño, una distribución desnivelada de los parásitos entre clases de tamaño de *N. lachneri* fue observada, sugiriendo una posible mortalidad inducida por el parásito. Debido a su rango restringido y estatus como posible especie que merece atención, creemos que los efectos de estos parásitos en la supervivencia y otros aspectos de la historia de vida y de la ecología de esta especie anfitriona justifican una investigación adicional.

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## LITERATURE CITED

- ANDERSON, R. M. 1978. The regulation of host population growth by parasitic species. *Parasitology* 76:119-157.
- ANDERSON, R. M. 1991. Populations and infectious diseases: ecology or epidemiology? *Journal of Animal Ecology* 60:1-50.
- ANDERSON, R. M., AND D. M. GORDON. 1982. Processes influencing the distribution of parasite numbers within host populations, with special emphasis on parasite-induced host mortality. *Parasitology* 85:373-398.
- BRONSETH, T., AND I. FOLSTAD. 1997. The effect of parasites on courtship dance in threespine sticklebacks: more than meets the eye? *Canadian Journal of Zoology* 75:589-594.
- BUSH, A. O., K. D. LAFFERTY, J. M. LOTZ, AND A. W. SHOSTAK. 1997. Parasitology meets ecology on its own terms: Margolis et al. revisited. *Journal of Parasitology* 83:575-583.
- DEGIUSTI, D. L. 1949. The life cycle of *Leptorhynchoides thecatus* (Linton), an acanthocephalan of fish. *Journal of Parasitology* 35:437-460.
- EWALD, J. A., AND B. B. NICKOL. 1989. Availability of cecal habitat as a density-dependent limit on survivorship of *Leptorhynchoides thecatus* in green sunfish, *Lepomis cyanellus*. *Parasitology* 98:447-450.
- GREGORY, R. D. 1990. Parasites and host geographic range as illustrated by waterfowl. *Functional Ecology* 4:645-654.
- HOFFMAN, G. L. 1967. Parasites of North American freshwater fishes. University of California Press, Los Angeles.
- HOLMES, J. C., AND P. W. PRICE. 1986. Communities of parasites. In: Kikkawa, J., and D. J. Anderson, editors. *Community ecology: patterns and process*. Blackwell Scientific Publications, Cambridge, Massachusetts. Pp. 187-213.
- HOUDE, A. E., AND A. J. TORIO. 1992. Effect of parasitic infection on male color pattern and female choice in guppies. *Behavioral Ecology* 3:346-351.
- JAENIKE, J., H. BENWAY, AND G. STEVEN. 1995. Parasite induced mortality in mycophagous *Drosophila*. *Ecology* 76:383-391.
- KENNEDY, C. E. J., J. A. ENDLER, S. L. POYNTON, AND H. McMINN. 1987. Parasite load predicts mate choice in guppies. *Behavioral Ecology and Sociobiology* 21:291-295.
- KENNEDY, C. R., A. O. BUSH, AND J. M. AHO. 1986. Patterns in helminth communities: why are birds and fish different? *Parasitology* 93:205-215.
- LIM, S. S. L., AND R. H. GREEN. 1991. The relationship between parasite load, crawling behaviour, and growth rate of *Macoma balthica* from Hudson Bay, Canada. *Canadian Journal of Zoology* 69:2202-2208.
- MARCOGLIESE, D. J., AND D. K. CONE. 1991. Importance of lake characteristics in structuring parasite communities of salmonids from insular Newfoundland. *Canadian Journal of Zoology* 69:2962-2967.
- MULLER, J. F., AND H. J. VAN CLEAVE. 1932. Parasites of Oneida Lake fishes. Part II. Descriptions of new species and some general taxonomic considerations, especially concerning the trematode family Heterophyidae. *Roosevelt Wildlife Annals* 3:79-137.
- PACALA, S. W., AND A. P. DOBSON. 1988. The relation between the number of parasite/host and host age: population dynamics and maximum likelihood estimation. *Parasitology* 96:197-210.
- PENNAK, R. W. 1989. Freshwater invertebrates of the United States: protozoa to mollusca. Third ed. John Wiley & Sons, New York.
- PETROCHENKO, V. I. 1971. Acanthocephala of domestic and wild animals, Vol. I. Greenberg, D., editor. Translated from Russian by Z. Blake. Keter Press, Jerusalem, Israel.
- POULIN, R. 1997. Species richness of parasite assemblages: evolution and patterns. *Annual Review of Ecology and Systematics* 28:341-358.
- PRICE, P. W., AND K. M. CLANCY. 1983. Patterns in number of helminth parasite species in freshwater fish. *Journal of Parasitology* 69:449-454.
- RICE, W. R. 1989. Analyzing tables of statistical tests. *Evolution* 43:223-225.
- ROBISON, H. W., AND T. M. BUCHANAN. 1988. Fishes of Arkansas. University of Arkansas Press, Fayetteville.
- ROBISON, H. W., AND G. L. HARP. 1985. Distribution, habitat, and food of the Ouachita madtom, *Noturus lachneri*, a Ouachita River drainage endemic. *Copeia* 1985:216-220.
- ROUSSET, F., F. THOMAS, AND F. RENAUD. 1996. Inference of parasite-induced host mortality from distributions of parasite loads. *Ecology* 77:2203-2211.
- SCHELL, S. C. 1985. Handbook of the trematodes of North America and Mexico. University Press of Idaho, Moscow.
- SCHMIDT, G. D. 1970. How to know the tapeworms. W. C. Brown Company. Dubuque, Iowa.
- STROMBERG, P. C., AND J. L. CRITES. 1974. The life-cycle and development of *Camallanus oxycephalus* Ward and Magath, 1916 (Nematoda: Camallanidae). *Journal of Parasitology* 60:117-124.
- STROMBERG, P. C., J. H. SHEGOC, AND J. L. CRITES. 1973. A description of the male and redescription of the female of *Camallanus oxycephalus* Ward and Magath, 1916 (Nematoda: Camallanidae). *Proceedings of the Helminthological Society of Washington* 40:234-237.
- TINSLEY, R. C. 1990. The influence of parasite infection on mating success in spadefoot toads, *Scaphiopus couchii*. *American Zoologist* 30:313-324.

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